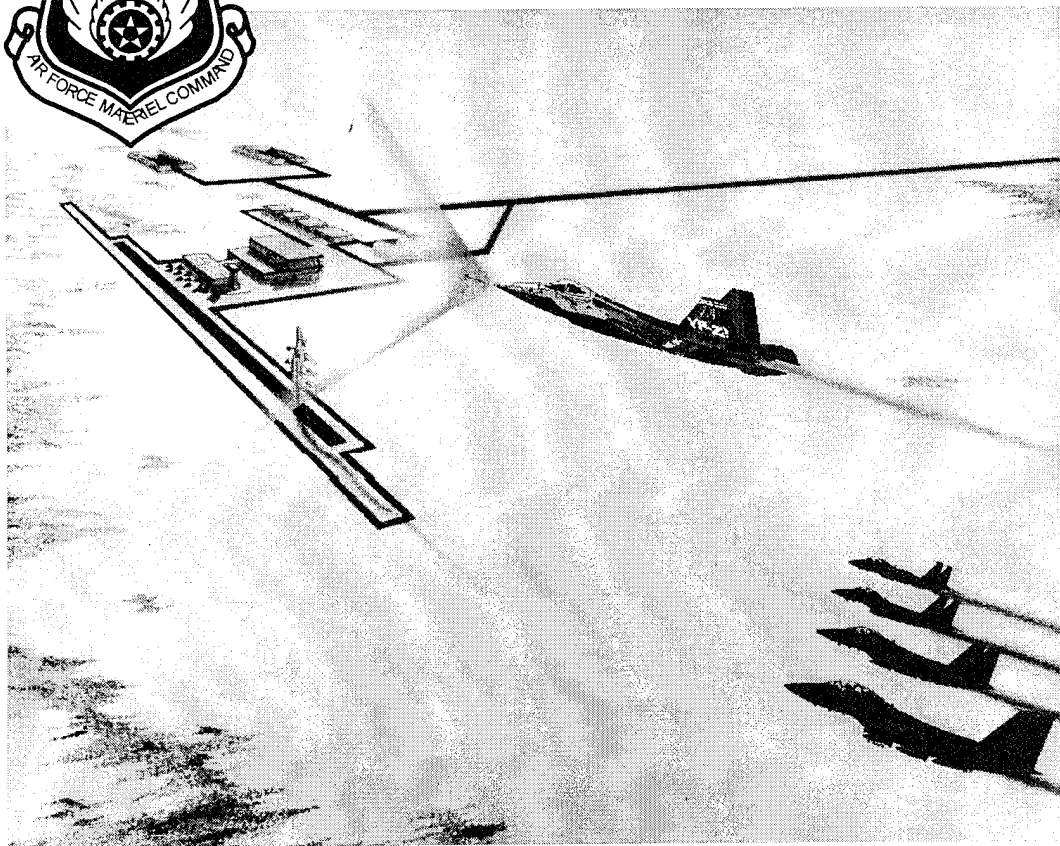
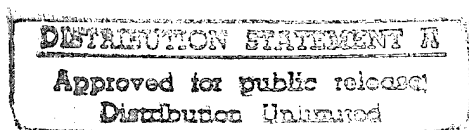


FY96

ADVANCED WEAPONS TECHNOLOGY AREA PLAN



HEADQUARTERS AIR FORCE MATERIEL COMMAND
DIRECTORATE OF SCIENCE & TECHNOLOGY
WRIGHT PATTERSON AFB, OH



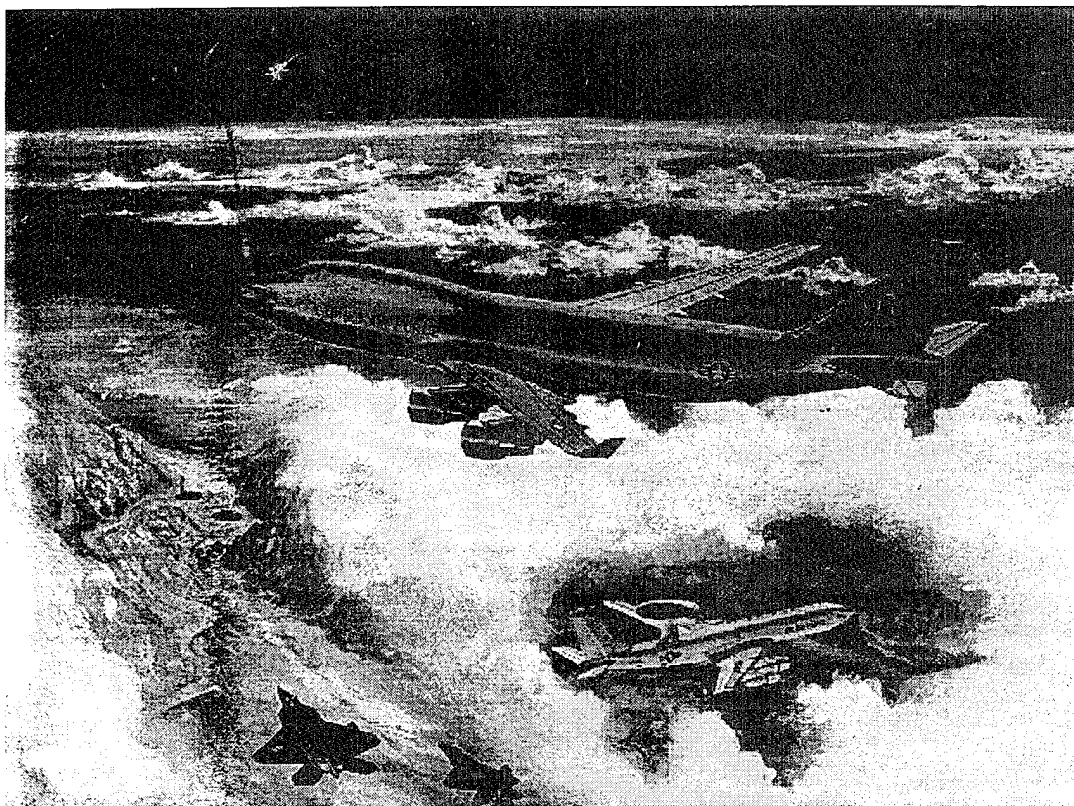
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14. Abstract The FY 96 Advanced Weapons Technology Area Plan describes Phillips Laboratory's exploratory and advanced technology development in laser technology, beam control, imaging, RF weapons, and space control assessments. Each of these thrusts is described in terms of its user needs, goals, major accomplishments, changes from last year, and milestones.					
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ADVANCED WEAPONS



VISIONS AND OPPORTUNITIES

The Phillips Laboratory (PL) develops and transitions war-fighting technologies in three primary areas: space and missile systems, geophysics, and advanced weapons. This Technology Area Plan (TAP) addresses the third of these three responsibilities, Advanced Weapons.

This Technology Area encompasses the development, demonstration, and transition of advanced weapons; the determination of the susceptibility of USAF systems to similar foreign threats; and the development of protection technology to enhance the survivability of USAF systems. On-going and planned R&D will lead to advanced weapon systems using high energy lasers, high power microwaves, high energy plasmas, and related capabilities such as high resolution optical imaging. Efforts in survivability assessment and protection technology involve the development of both hardening technology and the criteria for protecting USAF systems against directed energy weapons, space debris, and natural and enhanced space radiation.

As the Air Force center of excellence for advanced weapons, PL is well qualified to provide the technology for tomorrow's warfighters. Advanced weapons, particularly directed energy weapons (DEWs), offer the opportunity to leap-frog incremental advances in conventional weapons by providing revolutionary capabilities for both offense and defense. These technologies and the advanced weapon systems they make possible are a critical part of the Air Force's "Global Reach - Global Power" vision.

Within the Advanced Weapons Technology Area, PL develops moderate and high power laser devices; highly accurate optical acquisition, tracking, and pointing technology; high resolution optical imaging; moderate and high power electromagnetic weapons and countermeasures; and protection technologies. These application technologies are supported by on-going research in pulse power, high energy-density plasmas, nonlinear optics, target effects and vulnerability, survivability assessments, and systems performance and mission effectiveness analysis.

After years of investment, laser devices have reached a maturity which supports a clearly defined path to operational systems for both weapon and supporting applications. Realistic examples for weapon systems include high energy laser devices for ground-based laser antisatellite (GBL ASAT) and airborne theater missile defense (TMD) roles. Lightweight, compact, and efficient lasers at moderate power and selected wavelengths also are envisioned for a variety of applications, such as imaging, optical countermeasures, communications, illumination, target designation, and special operations.

The coming decade also will see a demonstrated capability in beam control systems. Continued progress in compensating for beam distortions due to atmospheric turbulence will provide the enabling technology for long-range laser weapon systems. The proven ability for high accuracy tracking and beam pointing give credibility to the precise application of energy at the speed of light to specific target aim points. With the combination of laser source and beam control technologies, the laser as a viable weapon system will come of age. We fully expect laser systems to proliferate in the Air Force inventory within the next ten years.

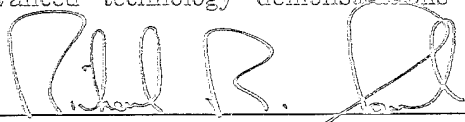
Maturing laser source and beam control technology is also the foundation for a revolution in optical imaging technology. Atmospheric compensation and illuminator laser technology, in combination with innovative image sensing and processing concepts, will greatly improve the coverage and resolution of imaging systems. Operational commands will routinely obtain high quality, timely imaging products for applications such as space object identification, long range airborne imaging of airborne and ground targets, and new technology approaches for space-based sensors.

High Power Microwaves (HPM) represent a major potential advance in Electronic Combat technology by extending conventional RF power output several orders of magnitude. This enables the damage and disruption of a much broader range of targets and simplifies the threat-specific nature of Electronic Combat systems. HPM can therefore not only attack multiple enemy communications and radar systems, but is also a potential generic countermeasure to a wide range of unfriendly IR and RF guided weapons. Several advanced technology demonstrations of HPM

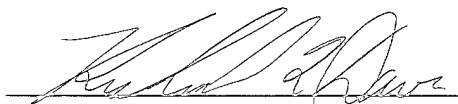
weapon concepts are planned in coordination with USAF operational users. This electronic sword works both ways, however, and protecting US electronic assets is equally important. This involves not only the careful design of US HPM weapons, but also hardening US assets against potential enemy HPM and other inadvertent RF threats. PL is at the forefront in developing RF susceptibility measurement and systems hardening technologies for transition to military users and industry. Finally, PL is pursuing pulse power development as a key enabling technology with long range potential for hypervelocity projectiles, weapons effects simulation, and extremely high power RF source drivers.

Integral to good S&T investment strategy and planning is the development of advanced technologies and tools that ensure cost effective survivability and sustainability of high-value space systems. Such is the future of the PL Space Control Assessment thrust. The Satellite Assessment Center develops and uses world-class modeling tools to complete unique survivability and vulnerability assessments for US and foreign space systems, subjected to a wide range of threat environments. Over the next few years we will fully integrate the survivability and vulnerability characteristics of additional satellites to directed energy and kinetic energy weapons into the Center's unique capabilities. Our research into RF technology for space control builds upon the technology base for terrestrial RF weapon applications. This research will provide important new options to deny the enemy's freedom to operate in space. We also anticipate significant contributions from our Spacecraft Interaction research and demonstrations. This multi-spectral sensing technology holds the promise of a new capability to significantly contribute to the space object identification mission. Continued space debris characterization will guide national policy on debris mitigation and protection.

PL's vision of the future in advanced weapons is one of providing major new military capabilities and shaping the nation's defense posture. With talented and dedicated professionals and modern research facilities, we stand ready to meet the challenge of military superiority in the next century.



RICHARD R. PAUL
Brigadier General, USAF
Technology Executive Officer



RICHARD W. DAVIS, Colonel, USAF
Commander
Phillips Laboratory

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This thrust assesses the vulnerability of foreign space systems in support of advanced weapon technology development programs, and defines the hostile threat space environments in which US systems will operate. The challenge is to determine the effects of advanced weapons, such as lasers and high power microwaves, on both foreign and US space systems and then to incorporate these findings into models and computer codes which predict space systems endurance and sustainability.	
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INTRODUCTION

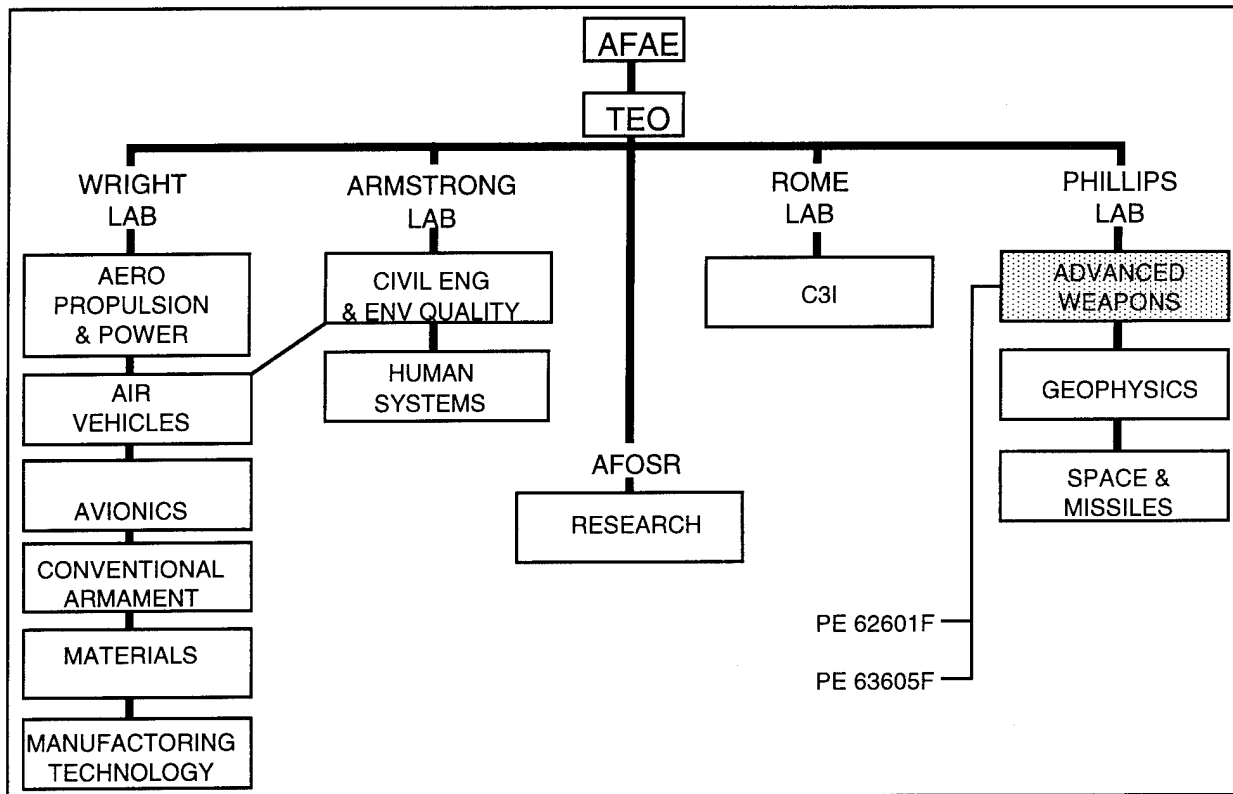


Figure 1. AF S&T Program Structure

BACKGROUND

The Advanced Weapons Technology Area is managed by the Commander of the Phillips Laboratory, as indicated in Figure 1. It is executed by the Advanced Weapons and Survivability and the Lasers and Imaging Directorates, with the majority of the technical activities performed at Kirtland AFB, New Mexico. This Technology Area encompasses the development, demonstration, and transition of advanced weapons and assessment of the survivability of USAF systems to similar foreign threats. For advanced weapon concepts, on-going and planned R&D will lead to high energy lasers, high power microwaves, high energy plasmas, and related capabilities such as high resolution optical imaging. Establishing the control and exploitation of space also requires the development of both hardening technology and the criteria for protecting USAF systems against directed energy weapons, nuclear weapons, and natural and enhanced space radiation.

Advanced Weapons is the one technology area where truly dramatic advances in war-fighting capabilities can occur. The ultimate goal

is new weapons development and transition, enabling the Air Force to leap over the on-going evolutionary development process for conventional weapons, and thereby provide superior capabilities to support our national security.

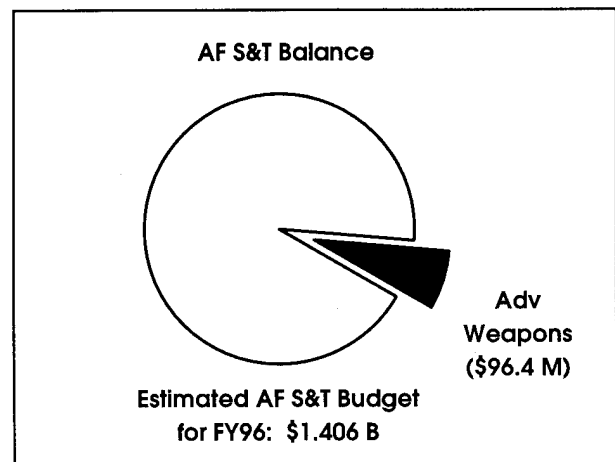


Figure 2. Adv. Weapons S&T Vs AF S&T

Figure 2 shows the estimated Air Force S&T budget for FY96, with the exploded segment showing those funds that are programmed for Advanced Weapons. The Advanced Weapons Technology Area is divided into the following five major Technology Thrusts:

1. LASER TECHNOLOGY
2. BEAM CONTROL
3. IMAGING
4. RF WEAPONS
5. SPACE CONTROL ASSESSMENT

The division of the Advanced Weapons Technology Area funding by major thrust is shown in Figure 3.

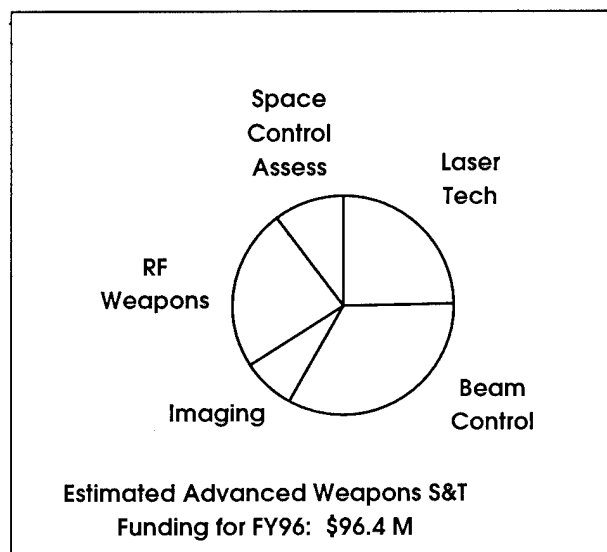


Figure 3. Major Technology Thrusts

Thrust 1: Laser Technology The overall goal of this thrust is to establish the feasibility and payoff of lasers in advanced weapon, communication, illumination, and optical countermeasure applications. Development efforts continue to address the concerns of scaling to high power, good beam quality, and high efficiency, but have recently included increased emphasis on suitability for specific classes of applications and operational environments. This has placed additional emphasis on operation in specific wavelength bands, packaging for minimum weight and volume, and reliability and affordability in real weapon system applications.

Development and testing of the Chemical Oxygen-Iodine Laser (COIL) at small scale continues to produce significant improvements in performance and lasing efficiency. By modifying the oxygen generator to increase flow rate and reduce excited oxygen residence times, the

amount of laser power per unit flow area has been improved by about 50%. Additionally, other tests have shown the feasibility of increasing the pressure in the optical cavity (thus reducing requirements for pumping) without significantly reducing laser performance and have also demonstrated the use of additional plastic components in the oxygen generator. Finally, lasing tests have begun on an advanced oxygen generator, based on uniform-droplet spray technology, with the potential to achieve further improvements in laser efficiency in a hardware configuration which is more suitable for thermal control and laser fuels recycling and regeneration. These tests establish a path for further development and scaling, to demonstrate a COIL technology base for reduced weight, volume, and fabrication costs for high power COIL devices in both ground-based and airborne applications.

Thrust 2: Beam Control The Beam Control thrust involves the development and transition of advanced optical systems for laser propagation and high resolution imaging applications. This includes technologies for adaptive optics, highly-accurate target acquisition and tracking, precision beam pointing for aimpoint control, and high quality optical components. A major effort under this thrust is the development and demonstration of weapon-class beam control technology for both ground-based and airborne laser systems.

At Starfire Optical Range (SOR), a new 3.5 meter telescope has been installed and activated, meeting or exceeding all jitter specifications. The development of the first-generation adaptive optics for this telescope is underway, with initial atmospheric compensation demonstrations planned for the summer of 1995. Additionally, a contract was awarded in early FY95 for the development of the second-generation adaptive optics, which will be delivered in FY97. This telescope and the associated adaptive optics hardware are central to the planned demonstration of integrated beam control technology for ground-based laser applications.

In support of Airborne Laser (ABL) beam control technology development, a series of ground field experiments have been completed, simulating the stressing turbulence conditions and propagation environment expected for the ABL theater missile defense scenario. These initial experiments used point sources for the adaptive optics and tracking beacons and successfully demonstrated both adaptive optics compensation and closed-loop tracking performance. These experiments will be repeated in late FY95 with more realistic extended sources for beacons.

Thrust 3: Imaging The Imaging thrust involves the development and transition of multi-spectral sensing and image processing technologies for high resolution imaging applications. This thrust takes advantage of adaptive optics and target acquisition/tracking technologies developed under the Beam Control thrust to produce a compensated, stabilized image which can then be further improved with advanced imaging sensors and post-processing of the image. Advanced concepts which can reconstruct images from interferometric or speckle data are also being pursued.

Using speckle imaging techniques, the first satellite images have been obtained with the new SOR 3.5 meter telescope. This technique, which uses computer post-processing to improve the quality and resolution of an image, will be extended with additional tests late FY95 to evaluate the synergistic effects on image quality of working with atmospheric compensation using adaptive optics. Successful results from these experiments will provide a technology for future upgrades of the imaging capabilities at operational optical sites for contribution to the space surveillance mission.

Thrust 4: RF Weapons The goal of the RF Weapons thrust is to develop and transition high power microwave (HPM) weapons technology into the AF operational inventory and to protect US systems against potential radio frequency (RF) weapons threats. Efforts include technology development and demonstrations of advanced HPM weapons, and development and transition of RF hardening techniques to AF Product Centers and industry.

Major milestones have been attained in demonstrating high power RF sources for a variety of wide- and narrow-band weapon applications-

- Aircraft Self Protection
- Suppression Enemy Air Defenses
- Command Control Warfare
- Counter Air
- Active Denial Technology

A RF effects and hardening database is being built in concert with AF Information Warfare Center, and PL has developed a totally automated RF effects capability to support this and related HPM weapons efforts. A detailed, two-year HPM effects assessment of a dedicated F-16 aircraft has also been successfully concluded.

Thrust 5: Space Control Assessments The Space Control Assessments thrust assesses the vulnerability of foreign space systems in support of advanced weapon technology development programs, and defines the hostile space threat environments in which US systems will operate. The challenge is to determine the effects of

advanced weapons, such as lasers and high power microwaves, on both foreign and US space systems and then to incorporate these findings into models and computer codes which predict space systems durability and sustainability.

RELATIONSHIP TO OTHER TECHNOLOGY PROGRAMS

The Advanced Weapons technology area interacts with several other technology areas through a wide range of relationships with other agencies. These relationships range from informal coordination between technical personnel to formal program management direction. Specific relationships are established through interchanges at technical meetings, seminars and symposia. If appropriate, they are formalized through Memoranda of Agreement or Memoranda of Understanding which delineate the responsibilities for supporting Advanced Weapons technologies.

The Advanced Weapons technology area benefits from support for basic research provided by the Research technology area. Individual tasks investigate a range of new technology concepts within four of the five major thrusts, with potentially high payoff for transition to longer-term development and scaling efforts. Examples include the investigation of novel, short wavelength laser concepts, adaptive optics phenomenology, basic physics issues for high performance optical coatings, aero-optics effects, advanced imaging concepts, and high energy pulse power.

There are many PL cooperative programs within the Air Force. In RF weapons they include Wright Labs on IR missile countermeasures, Rome Labs on Information Warfare (IW), Armstrong Labs on Active Denial Technology, AEDC on RF test facilities for satellites, and an Air Staff sponsored program on Information Warfare protection and hardening. Rome Laboratories is pursuing the development of acquisition, tracking, pointing-fire control algorithms and the Materials Directorate, WL, is pursuing development of high power optical component technology, both of which are directly relevant to the goals of the Beam Control thrust.

Among the Services, work in this technology area is coordinated among the Services through the Technology Panel for Directed Energy Weapons (TPDEW) of the Joint Directors of Laboratories Committee (JDL). RF weapons coordination has included transition of AF HPM sources to Army programs, leverage of RF effects tests on communications gear and missiles for AF programs, and cooperation on large aircraft RF

effects tests and wide band source development at Naval Surface Warfare Center. There is also agreement among the services that the AF will support the development of adaptive optics technology for atmospheric compensation, with the resulting technology base available to the other services to support their applications.

There is also a significant degree of cooperative work with other government agencies and their laboratories. Department of Energy (DOE) laboratory representatives participate in JDL TPDEW meetings to improve coordination and identify areas for cooperation. For example, cooperative or collaborative work exists with DOE laboratories on pulse power, compact HPM source development, RF effects tests, power beaming technology investigations, specialized security sensor development, RF coupling code development, and mid-IR semiconductor laser diode development. Power beaming, long range laser communications, and RF coupling code development are also being investigated in cooperation with NASA.

PL S&T investments are significantly enhanced by teammates in the industrial sector. There has been continuing emphasis on technologies oriented to airborne laser systems, stimulated by the establishment of the ABL program and the award of ABL Concept Definition Studies in mid-FY94. There also continues to be significant investment by industry in the area of high energy chemical lasers, advanced optical imaging, semiconductor laser diodes, HPM sources, and RF hardening. A close relationship with industry is also illustrated through a number of active Cooperative Research and Development Agreements in areas such as laser development for materials processing and medical applications, optical coatings process development, HPM source development, and RF effects testing and hardening of commercial vehicles (GM), aircraft (Boeing), and satellites (Teledesic).

PL manages the SMC Small Business Innovative Research (SBIR) program. Planned efforts in Advanced Weapons include at least 45 efforts addressing specific technologies in DEW, imaging systems, and weapons survivability. In proposing topics for the SBIR program, one of the strong considerations has been the potential for commercialization of the potential product, as well as the innovation required for a solution. This concept maximizes the potential gain for both the small business and the government.

Interactions with international R&D programs are productive in essentially all areas of research within the Advanced Weapons Technology Area. The interaction ranges from the exchange of data and information in areas of

common interest, through the funding support of specific research initiatives in foreign countries, to the joint support of specific research and testing initiatives. A total of 10 different international agreements are involved, with an estimated dollar value exceeding \$1 million.

CHANGES FROM LAST YEAR

The ABL beam control technology program has been revised in some respects to address issues which have been raised during the past year from initial field testing of beam control technology. Specifically, tracking technology efforts have been enhanced to add additional tests of tracking concepts and algorithms in a dynamic tracking environment which simulates that of the ABL theater missile defense scenario.

The HPM Aircraft Self Protection program has expanded, and now encompasses both Air Combat & Mobility Commands' requirements for IR countermeasures (IRCM). The RF effects portion has also grown, and this effort is now fully integrated with Wright Labs' IRCM program. Projected HPM field demonstrations are now scheduled for FY98 completion. HPM command and control warfare has also grown because of the increased emphasis on Information Warfare by the Air Force and Joint Staff. HPM command and control warfare has also assumed responsibility for overall AF wide band source technology development.

THRUST 1: LASER TECHNOLOGY

USER NEEDS

This thrust supports the following mission areas and associated technology needs or deficiencies as provided in the current Mission Area Plans (MAPs):

Air Force Space Command

- Counterspace/Space Control: counterspace (negation) capability-Antisatellite (ASAT).
- Command & Control/Force Application: no current weapon systems-high energy lasers.
- Command & Control: satellite communication crosslinks (laser).
- Space Surveillance: limited space intelligence support (SOI, MPA, imagery, status assessment).

Air Combat Command

- Theater Missile Defense: attack and kill capability-Airborne Laser (ABL).
- Counter Air: laser IR countermeasures.

Air Force Special Operations Command

- Joint Air-SOF Battlefield Interface: secure, antijam, low probability of intercept/low probability of detection (LPI/LPD) communications.
- Combat Support: enhanced medical field laser system; security police directed energy weapon (DEW) capability; reliable, pocket-size, chemical detection device; chemical standoff detection system.
- Force Application: future gunship weapons-lasers; limited IR countermeasures (IRCM); nonlethal weapons technology/area denial; enhanced target identification capability.

Air Mobility Command

- Airlift/Air Refueling: advanced IRCM.

GOALS

The overall goal of the Laser Technology thrust is to demonstrate and establish the feasibility and payoff of lasers for military applications and transition the technology to meet user needs.

Specific goals include:

- Demonstrate Chemical Oxygen-Iodine Laser (COIL) device scaling, high pressure operation, and extended run times for applicability to high power DEW systems, with emphasis on ground-based laser ASAT and ABL TMD missions.
- Demonstrate scaling, packaging, weight reduction, and gravity-independent operation technologies to allow COIL devices to be used for ABL TMD missions.
- Transition semiconductor diode laser sources, when suitable, to satellite crosslink communication developers.
- Demonstrate and transition lightweight, compact, high efficiency semiconductor diode and diode-pumped lasers to meet customer needs in the areas of communications, remote and environmental sensing, terrestrial illumination, nonlethal weapons, medical applications, and countermeasures.
- Develop advanced laser sources, e.g., new gas phase lasers; high repetition rate, ultra-short pulse lasers, etc., for high payoff applications where current laser source state-of-the-art fails to meet application requirements.
- Develop high power frequency agile sources in the near ultra-violet, visible and near infrared using nonlinear optical processes.

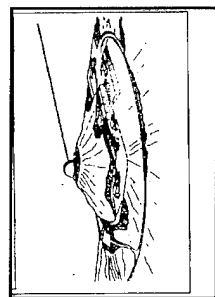
MAJOR ACCOMPLISHMENTS

Significant progress was made in FY94/95 in the area of high power semiconductor laser arrays and single devices. In addition to phasing of 900 amplifiers in a master oscillator power amplifier configuration, approximately 1000 lasers have been phased aligned in an external cavity configuration. The external cavity configuration relieves the on-the-chip phase control issues, since the external cavity controls the phases, resulting in a potentially much simpler device. These results will provide opportunities for semiconductor lasers to meet application requirements involving high power, including long range laser communication, optical countermeasures, area denial, high power illuminators for enhanced target identification, and directed energy weapons.

Progress in the single device program has resulted in 10 W (continuous wave) of good beam



ADVANCED WEAPONS LASER TECHNOLOGY



GBL ASAT
SYSTEM

TECHNOLOGIES

USERS

LASER
TECHNOLOGY
APPLICATIONS

SCALABILITY
WAVELENGTH
AGILITY
PACKAGING
(WEIGHT & VOLUME)
RELIABILITY &
MAINTAINABILITY

CHEMICAL OXYGEN-
IODINE LASERS
ACC, AFSOC
DIODE-PUMPED
SOLID-STATE LASERS
ACC
SEMICONDUCTOR
LASERS & ARRAYS
ACC, AFSOC
ADV LASER
CONCEPTS
AFSPC

PROLIFERATE
LASERS IN AF
SYSTEMS
INVENTORY



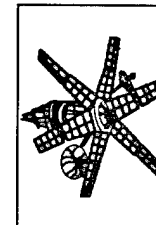
IMPROVED MED-
SURGICAL LASER



ABL FOR THEATER
MISSILE DEFENSE



AIRCRAFT
SELF-PROTECTION



SBL FOR IMAGING
AND WEAPON
APPLICATIONS

95

96

97

98

99

00

01

02+

quality output from a broad-area emitter. Transition of these devices will continue, to provide near-term application solutions for laser communications, remote/environmental sensing, and medical applications. These high-power single devices will also provide the building blocks for incorporation in array architectures to achieve very high powers. Two new contracts have begun this year that will incorporate the new high power single devices into arrays to yield phased arrays capable of 50-100 W (continuous wave), diffraction limited output at the end of FY96.

In FY94/95, a mid-IR laser at 4 microns with an average power output of 150 mW was demonstrated. This is a significant step in the development of compact, efficient laser sources for wavelength-specific applications such as eye-safe illuminators and IR countermeasure missions.

Major accomplishments in the ultra-fast laser, semiconductor interactions included the experimental observation of strong Tera Hz (1×10^{12}) enhancement from indium antimonide (InSb) with longer wavelengths; the acquisition of carrier dynamic behavior of IR photosensitive materials at 1 to 2 micrometers wavelength; and the demonstration of opto-electrical properties of InSb in response to sub-100 femtosec radiation. These experimental accomplishments provide the first steps in the understanding of ultra-fast phenomena in photosensitive materials. Potential future applications of this technology may be in the area of ultra-fast communication.

The design and analysis of a moderate-power sodium wavelength laser source has been completed, for potential application as a beacon laser for atmospheric compensation. The design uses a parametric oscillator, followed by parametric amplifiers and a sum frequency nonlinear crystal, to produce the desired wavelength. The nonlinear frequency converters are pumped by a specially designed, compact, diode-pumped solid-state laser.

CHANGES FROM LAST YEAR

The only significant change since last year for this thrust is the acceleration of the high power frequency agile laser source task, to meet the requirements of the ground-based laser program.

MILESTONES

The development and demonstration of COIL device technology to meet the requirements of GBL ASAT and ABL TMD missions requires advanced oxygen generator technology to achieve high output power and long run-times. On-going development of an advanced generator will continue through FY95, with final scale-up and demonstration on a scaled in-house device in

FY97. Demonstration of advanced, high performance COIL mixing nozzles is planned for FY95 and promises increased energy extraction and an associated 25-30% increase in device output power. Additional efforts addressing specific ABL TMD issues include high pressure device operation and laser reactant recycling/regeneration. These efforts will be completed in FY96.

Single semiconductor laser diode technology development will continue in FY96 to obtain devices with up to 10 watts continuous output and good beam quality. These devices will be transitioned to meet near-term user needs. Semiconductor laser diode array efforts will continue to focus on parallel edge and surface emitting array scaling architectures throughout FY96, as well as the incorporation of advances in single diode technology. Downselection between the two parallel approaches will occur in FY96 for the development of a major demonstration system in FY97. This system will incorporate a number of technologies, including high power single device and coherent array technology to achieve a 100-200 watt laser device. In FY96, lasing at the 3 micrometers wavelength, while operating at room temperature, is anticipated. Thermal electric cooler lasing at 4 micrometers wavelength is expected in FY97. Advances in mid-IR laser source technology are now being transitioned to users for a number of applications including countermeasures.

High power diode-pumped laser efforts will continue, with a 1 kilowatt device planned for delivery by the end of FY95, and a 3 kilowatt device in FY97. These devices will support a number of applications, including high power illuminators for GBL ASAT and ABL TMD missions.

A 50 W sodium wavelength source is scheduled for delivery in FY96, to support laser beacon source requirements for atmospheric compensation field experiments under the Beam Control Thrust. This will be increased to 200-W by FY98, to support the GBL Integrated Beam Control Demonstration in FY99.

Efforts on the theoretical and experimental investigation of Tera Hz radiation from InSb-n junctions will conclude in FY96. Performance of Fourier Transform spectroscopy experiments of Tera Hz radiation from photosensitive material will conclude in FY96. The study of the propagation of sub-100 femtosec laser pulses will continue to FY98, and the investigation of Tera watt ultra-short laser, non-linear, Tera Hz radiative effects is scheduled to last from FY96 through FY00. A variety of nonlinear optical methods is being investigated for the purpose of producing, by FY02, a high power source (1000 W) that is tunable in the near-ultraviolet, visible and near infrared wavelength ranges.

THRUST 2: BEAM CONTROL

USER NEEDS

Beam control technology is central to the realization of essentially all applications of laser and optical imaging systems, because the beam control system functions to deliver the beam from the laser device to the transmitting aperture, correct for optical and atmospheric-induced distortions, acquire and track the intended target, and point the beam to the designated target aim point. Combined with the appropriate laser sources or imaging sensors, this thrust supports the following user needs, as stated in current Mission Area Plans:

Air Force Space Command

- Counterspace/Space Control: counterspace (negation) capability - Antisatellite (ASAT).
- Command & Control/Force Application: no current weapon systems - high energy lasers.
- Space Surveillance: limited space intelligence support (SOI, MPA, imagery, status assessment).

Air Combat Command

- Theater Missile Defense: attack and kill capability - Airborne Laser (ABL).

GOALS

The overall goal of the Beam Control thrust is to develop and transition advanced optical systems and technologies for both laser propagation and high resolution imaging applications. This includes efforts to:

- Establish the technology base for atmospheric compensation for applications such as GBL ASAT, ABL TMD, and imaging in the late 90's.
- Develop and demonstrate critical optical acquisition, tracking, and pointing technology for high energy laser systems and to stabilize the image plane for optical imaging applications such as space object identification.
- Develop and demonstrate key high energy laser optical component technologies to enable advanced weapon applications.
- Develop and validate the modeling and simulation tools needed for accurate performance and mission effectiveness assessments.

MAJOR ACCOMPLISHMENTS

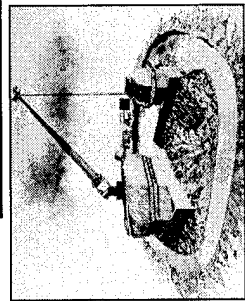
On-going field experiments at Starfire Optical Range (SOR) have continued, to evaluate adaptive optics and tracking hardware in a field environment and to develop and upgrade the hardware for future, more capable testing and demonstrations. In late FY94, a field test series called the Point-Ahead Compensation Experiment (PACE) was started on the 1.5 meter telescope, using binary stars to measure and demonstrate compensation for tilt anisoplanatism, a significant technology issue for GBL systems. Tilt anisoplanatism is a degrading effect which is introduced because of the point-ahead nature of a satellite engagement. Because the out-going laser beam must be aimed ahead of the apparent position of the satellite, the track jitter sensed by a satellite tracking system is not in exactly the right direction. The error introduced by improperly sensing the tilt component of atmospheric turbulence distortions is referred to as tilt anisoplanatism. Initial experimental results indicate that compensation should be possible, with demonstration of compensation planned for the last half of FY95.

With the activation of the new SOR 3.5 m telescope and facility in FY94, efforts have concentrated on the development of the associated adaptive optics. The first-generation adaptive optics system is proceeding, with initial atmospheric compensation experiments on the 3.5 meter telescope planned for the summer of 1995. This first-generation system uses a total of 577 subapertures, which is scaled from the 241 subaperture system currently in use on the 1.5 meter telescope. The contract for the second-generation adaptive optics system was awarded to Hughes Danbury Optical Systems in early FY95, with hardware delivery planned for FY97. The second-generation system, with 900 subapertures, will allow the demonstration of weapons-class atmospheric compensation performance as part of GBL integrated beam control demonstrations on the SOR 3.5 meter telescope.

Supporting ABL technology requirements, the first series of ground propagation experiments have been completed in an environment which simulated the stressing turbulence conditions expected in the ABL TMD scenario. These experiments demonstrated adaptive optics compensation and closed-loop tracking performance using point sources for the adaptive optics and tracking beacons. Additional ground experiments are planned in late FY95 with more realistic extended source beacons.



ADVANCED WEAPONS BEAM CONTROL



Starfire
Optical Range

REDUCED
COMPLEXITY,
IMPROVED
PERFORMANCE

INTEGRATED
DEMO OF
ALL BEAM
CONTROL
FUNCTIONS

ATMOSPHERIC
COMPENSATION
INDEPENDENT
OF TARGET

SUB-
MICRORADIAN
ACQUISITION,
TRACING, AND
POINTING

HEL OPTICAL
COMPONENTS

LASER
WEAPONS AND
HIGH
RESOLUTION
OPTICAL
IMAGING
SYSTEMS

TECHNOLOGIES

USERS

BEAM
CONTROL
APPLICATIONS

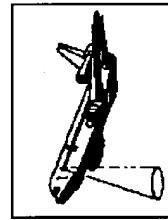
HIGH POWER
OPTICS
ACC

PRECISION
TRACKING
ACC

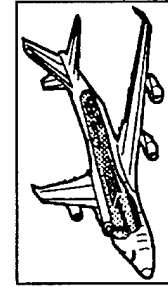
ADAPTIVE OPTICS,
BEACON SENSING
AFSPC

BEAM CONTROL
INTEGRATION
AFSPC

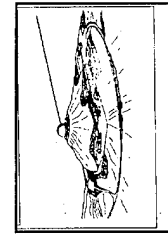
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AFSPC



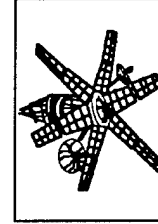
NLO IMAGING
BRASSBOARD



ABL FOR THEATER
MIEEILE DEFENSE



GBL ASAT



SBL FOR IMAGING
AND WEAPON
APPLICATIONS

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02+

Flight experiments have begun to obtain critical atmospheric measurements for the ABL program. These experiments, called the ABLE ACE flight tests, will be flown on the Argus aircraft and will involve a series of airborne optical measurements of turbulence along the high altitude, horizontal propagation paths which characterize the TMD scenario. The preparation for these experiments is in itself a major accomplishment, as it involved the development and integration into the aircraft of complex laser and optical receiver systems capable of making the required high-resolution measurements of atmospheric turbulence over several hundred-kilometer propagation paths.

CHANGES FROM LAST YEAR

The ABL beam control technology program has been revised in some respects to address issues which have been raised during the past year from initial field testing of beam control technology. Specifically, tracking technology efforts have been enhanced to add additional tests of tracking concepts and algorithms in a dynamic tracking environment which simulates that of the ABL TMD scenario. These tests are planned to use existing beam control system hardware -- the Navy's Sea Lite Beam Director (SLBD), located at White Sands Missile Range (WSMR), and the High Altitude Balloon Experiment (HABE) active tracking system, which will be deployed to WSMR in FY96. Both the SLBD and HABE tracking experiments will capitalize on a large of ballistic missile launches planned by the Army at WSMR in 1996 and 1997 so that active tracking performance data can be obtained against thrusting boosters.

MILESTONES

Many activities in this thrust converge to full-scale demonstrations of GBL beam control technologies in FY99. These demonstrations will be conducted on the new 3.5 m telescope, which was activated at SOR in early FY94.

The development of the first generation adaptive optics system for the 3.5 m telescope is planned to be complete in FY95. The first demonstration of closed-loop atmospheric compensation performance is planned for the last half of FY95, followed by compensation experiments using the full-scale laser beacon geometry starting in FY96. Finally, upgrades to the adaptive optics system will be integrated in FY97, leading to full-scale, low power field tests of atmospheric compensation technology appropriate for GBL applications in FY98-9. The metric for these demonstrations will be the degree

of compensation achieved, compared with weapon system requirements.

High bandwidth, passive tracking of satellites was initially demonstrated on the 1.5m telescope at SOR in early FY94. In FY93, work also began (under the Laser Technology thrust) to develop a near-infrared illuminator laser device, to be installed at SOR in late FY95 to support high accuracy active tracking field experiments. Work in parallel on tracker upgrades and aim point designation and control algorithms will be incorporated, leading to full-scale, low power field tests of acquisition, tracking, and pointing technology appropriate for GBL applications in FY97-8. In this case, the performance metrics are the residual tracking error and the beam pointing accuracy which can be achieved against realistic satellite targets.

The final demonstrations for GBL beam control will emphasize integrated performance of the overall beam control system, including all of the functions necessary for a satellite engagement (acquisition, tracking, pointing, and atmospheric compensation). The goal is to demonstrate integrated performance which meets the requirements for a full-scale GBL system, thereby establishing the maturity of beam control technology for these application. These integrated demonstrations will be completed in FY99.

To address ABL beam control technology requirements, a significant milestone is the completion of the atmospheric measurements program, which will conclude with wavefront sensor measurements of turbulence statistics along the high altitude, horizontal propagation path which characterizes the TMD scenario. These tests and the associated data analysis, beginning in FY95, will be completed in FY96. The metric is the completeness of the turbulence characterization data, as a critical input to the ABL system concept definition studies.

Dynamic tracking tests, using real ballistic missiles in the boost phase as the targets, will be conducted at WSMR during FY96 and FY97. These tests will demonstrate concepts for ABL active tracking, including the demonstration of initial passive acquisition of the boosting missile, hand-off to active tracking of the missile body, tracking signal-to-noise, and tracking algorithms.

There are several optical component development efforts in progress to support beam control requirements. Work will continue in the development of high performance coatings, with the goal of meeting reflectivity, scatter, and durability requirements in FY95. Scaling of concepts for critical optical components, including a low-flow mirror design, cooled windows, and aperture sharing elements, will begin in FY95, with the delivery and laboratory evaluation in FY96/97.

THRUST 3: IMAGING

USER NEEDS

This thrust supports the following mission areas and associated technology needs or deficiencies, as provided in the current Mission Area Plans (MAPs), through the development of advanced imaging and remote sensing techniques. Involved are passive and active (laser illumination of targets) methods to improve the resolution, extend the time availability, and reduce turn-around time for space surveillance data. Conventional and nonconventional methods are being developed to increase the information obtainable by the optical observation system and to increase the range from low earth orbit (LEO) to geosynchronous (GEO) altitudes. Additional efforts address the improvement of airborne and space-based imaging systems.

Air Force Space Command

- Space Surveillance: Inadequate continuous near Earth coverage; inadequate continuous deep space coverage; limited coverage (multi-phenomenology); limited space intelligence support (SOI, MPA, imagery, status assessments).
- Command and Control: Surveillance coverage; deep space surveillance.

Air Force Special Operations Command

- Joint Air-SOF Battlefield Interface: No real/near time imagery from National Systems.
- Force Application: No real time imagery for target study; no en-route real time imagery; enhance target identification capability.
- Psychological Operation: No real/near time imagery from National Systems.

GOALS

The overall goals of the Imaging thrust are to develop and transition advanced optical systems and multi-spectral sensing technologies for tactical and/or strategic applications to meet user needs in the areas of quality optical imagery and remote sensing. Specific goals include:

- Develop active imaging techniques to obtain images of LEO objects, and extend these technologies to reach deep space or GEO objects.

- Develop passive imaging techniques to obtain images of low earth orbit objects, and extend these technologies to reach deep space or geosynchronous objects. Provide processed data to users to satisfy near earth and deep space surveillance needs.

- Develop advanced electro-optical devices to support other Air Force missions, including long range laser target designators, optical reconnaissance and surveillance of chemical and biological weapons in production or in use on the battlefield.

- Develop nonlinear optical systems to automatically correct for dynamic optical errors introduced by the atmosphere, and to correct for static errors to very large diameter, lightweight, deployable primary mirrors on imaging satellites.

MAJOR ACCOMPLISHMENTS

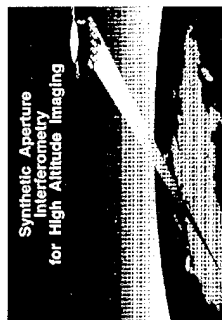
Several major accomplishments during the past year have contributed significantly toward the achievement of technical goals, and hence toward meeting stated user needs and deficiencies. These accomplishments range from the successful completion of laboratory proof-of-principle experiments to the demonstration of techniques in realistic field experiments. Efforts directed toward meeting the needs of extending the time availability of surveillance coverage included construction of an optical simulation package for adaptive optics under daylight conditions, and, for active imaging applications, the demonstration of a beam quality of 1.2 times diffraction limit in illuminator laser development. Hardware for an active imaging field experiment has been constructed, which will allow the first-ever detailed measurements of the light returned from laser-illuminated satellites.

A significant accomplishment in the development of alternate technology for active imaging is the construction and full system integration of the High Power CO₂ LADAR Surveillance Sensor (Hi-CLASS) system at the Air Force Maui Optical Station (AMOS). In its initial capability configuration, the Hi-CLASS system provided the first test results for Doppler imaging.

The Fast Optical Tomography of Turbulent Organized Structures system successfully completed its first year milestone by using Hartmann wavefront sensor data to produce the first tomographic reconstruction (a volume image, similar to that produced by a CAT scan in medical



ADVANCED WEAPONS IMAGING TECHNOLOGY



HIGH RESOLUTION
AIRBORNE IMAGING
AND REMOTE
SENSING FOR
TACTICAL
APPLICATIONS

HIGH RESOLUTION
IMAGING FOR GEO
SATELLITES

24-HOUR LEO
IMAGING DEMO

HIGH RESOLUTION
IMAGING OF SUN-
ILLUMINATED LEO
SATELLITES

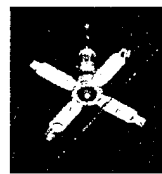
OPERATIONAL
APPLICATIONS
OF HIGH
RESOLUTION
OPTICAL
IMAGING
CAPABILITIES

TECHNOLOGIES

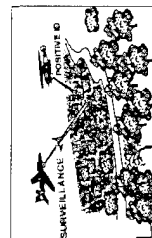
USERS

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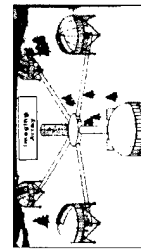
PASSIVE ACTIVE REMOTE SENSING NON-CONVENTIONAL
AFSPC AFSOC, ACC AFSPC AFSPC



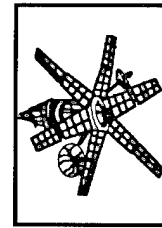
LEO SPACE
SURVEILLANCE



AIRBORNE TACTICAL
SURVEILLANCE, RECON



GEO SPACE
SURVEILLANCE



SBL FOR IMAGING
AND WEAPON
APPLICATIONS

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applications) of a high speed (5 m/s) gas flow. This measurement capability should lead to a greatly-improved understanding of the interaction of optical propagation with turbulent air flows, with the potential to improve the resolution of optical imaging in airborne applications

The AMOS Daylight Optical Near-Infrared Sensor became operational at the AMOS site, extending the capability for passive imaging of satellites several hours into the daylight regime. Images from this new sensor are now provided on a daily basis to Air Force Space Command. Additionally, the first computer-compensated images of a satellite were produced using the phase diversity image-processing algorithm and the uncompensated 1.2 meter telescope at AMOS. The resulting image quality was nearly as good as that from the AMOS 1.5 meter telescope, which is compensated with adaptive optics

The All-Optical Imaging Brassboard has concentrated on producing and characterizing an atmospheric laser beacon as a reference source for correcting optical distortions introduced by propagation through the extended atmosphere. The weak return from the beacon has been amplified using a nonlinear optical process to the level required to form a hologram of the optical distortions. This is a key step in proving the effectiveness of nonlinear optics in a real-time image compensation system.

CHANGES FROM LAST YEAR

Progress in the past year's research, increased Space Command interest in imaging deep space objects, and budget cuts for FY96 and FY97 have forced modification of this effort. To make the best use of limited funds, the technology areas are now structured in terms of technology development goals rather than mission applications. The Active Imaging subthrust now covers all active imaging and remote sensing of space objects. The Passive Imaging subthrust covers all passive imaging and remote sensing of space objects. Additionally, elements of the passive and active imaging subthrusts have been combined to address the remote optical sensing application for long-range standoff detection. The new focus includes chemical warfare agent detection and identification biological warfare agent detection and identification, counter-proliferation, intelligence preparation of the battlefield through effluent characterization, counter drug, critical mobile target detection, underground facility characterization, identification friend or foe, and battle damage assessment. Specific technical initiatives are hyperspectral sensors in the thermal region and light detection and ranging (LIDAR) systems for airborne and space assets.

MILESTONES

Two major efforts to increase the continuity and quality of space surveillance data are continuing. A passive technique, compensated daylight imaging, builds upon the results of field tests at Starfire Optical Range and on improved image processing algorithms, and will be used to demonstrate imaging of ultra-dim objects in FY97 at AMOS. Continuing improvements in sensor and adaptive optics systems will also provide the technology for an improved operational capability at the Advanced Electro-Optical Sensor (AEOS). AEOS is a new, 3.67 meter telescope which is currently under development and will be operational at the AMOS site in FY97.

The second effort, funded through a Congressionally-directed initiative, is the development of an Active Imaging Testbed. With continued funding support, the completion of illuminator laser development, the integration of optical receiver hardware, and the demonstration of a limited active imaging capability is planned for the end of FY96. Follow-on experiments will refine LEO imaging techniques and will start the experimental development of GEO imaging techniques. Subsequent active imaging work will extend the capability to GEO targets, with anticipated start of tests during FY00.

A full capability Hi-CLASS system is expected to be on line at AMOS during FY96. This system will be used to demonstrate Doppler imaging of LEO satellites and evaluate the potential for use out to GEO satellite altitudes.

Another candidate technique to extend imaging capability to GEO orbits is interferometric imaging. Near-term efforts will concentrate on the development of enabling technologies for this passive deep space imaging technique. Considering all passive and active imaging concepts, the most promising technique for GEO imaging will be selected during FY98. For the selected concept, further development will then concentrate on achieving the field demonstration of a GEO imaging capability.

Airborne hyperspectral measurements and LIDAR demonstrations planned for FY96 will support the development and demonstration of an airborne testbed for active remote sensing for reconnaissance and surveillance of chemical weapons in production or use on the battlefield.

A non-conventional imaging method intended for ground- and space-based applications utilizes nonlinear optics to remove atmospheric and large optic figure errors from a signal. To evaluate this concept, the All-Optical Imaging Brassboard will be integrated into the SOR 1.5m telescope during FY96. System concepts for ultra-high resolution satellite imaging will be tested in the laboratory during FY96, and field tested during FY97.

THRUST 4: RF WEAPONS

USER NEEDS

ACC, AMC, and AFSOC have mission requirements for RF weapons in Mission Area Plans and Roadmaps. Needs have been examined by the Product Centers' TPIPTs, and documented in their TIRRs. The following summarizes user needs for RF Weapons:

- Counter Surface-to-Air & Air-to-Air Missiles
- Large Aircraft IR Countermeasures
- Suppression of Enemy Air Defenses
- Air Interdiction of C4I Defenses
- Degrade Enemy Air Control
- Degrade Enemy Military Base Operation
- Reduce Enemy Sortie Generation
- Hardened Target Weapons
- Agent Defeat Warheads
- Less-Than-Lethal Weapons

RF Effects and Hardening is a pervasive need driven by requirements at several different levels. The Operational Commands and Air Logistic Centers (ALCs) have articulated their user level needs for RF Effects Systems Survivability. The Phillips Lab is the prime executor of high power RF effects and Hardening programs, and, as required, supports customers in more general EMI/EMC efforts. In addition, MAJCOMs and other users have long term needs which include:

- Agent Defeat Technology
- Space Debris Simulation
- X-ray Simulator Development

Finally, the RF Weapons (Thrust 4) and Space Control Assessments (Thrust 5) are interlinked. AFSPC has a strong need for Thrust 4 RF effects and hardening technologies for protection of satellites and SATCOM ground-link equipment. Thrust 5 is also dependent on Thrust 4 for HPM source technology.

GOALS

The overall goals of the RF Weapons thrust are to develop and transition RF weapons technology into the operational inventory, and to protect US systems against the expanding threat represented by similar foreign systems. The Weapons portions of this thrust is organized under five Mission Application programs which perform research in response to user needs. These programs will provide revolutionary rather than incremental advances in friendly force capabilities.

- HPM Aircraft Self Protection (ASP)
 - Counter Surface-to-Air & Air-to-Air Missile
 - Large Aircraft IR Countermeasures
- HPM Suppress Enemy Air Defenses (SEAD)
- HPM Command Control Warfare (CCW)
 - Air Interdiction of C4I Assets
 - Degrade Enemy Air Control
 - Degrade Enemy Military Base Operation
 - Hardened Target Weapons
- HPM Counter Air (CA)
 - Reduce Enemy Sortie Generation
 - Degrade Enemy Military Base Operation
- RF Active Denial Technology
 - Less-Than-Lethal Weapons

The RF Effects and Hardening programs are organized into many overlapping technology efforts which includes

- RF Environments & System Responses
- RF Test & Measurement Techniques
- RF Protection Techniques
- RF Standards, Handbooks, & Design Guides
- Hardness Maintenance/Hardness Assurance
- Planning & Execution of Systems Level Tests

The result is a fully integrated approach to RF Systems Effects, Vulnerability, and Lethality, covering natural, inadvertent man-made, and potential hostile RF weapons threats.

Enabling Technologies are pursuing long range goals in conducting a number of exploratory research programs.

- Solid Liner Implosions
 - Agent Defeat Warhead Technology
 - Space Debris Simulation
 - Micro Fission/Micro Fusion Technology
- Compact Toroids
 - Low Cost X-Ray Simulator Development
- High Power/Fast Switch Testbed
 - Long Range, Second Generation RF Weapons

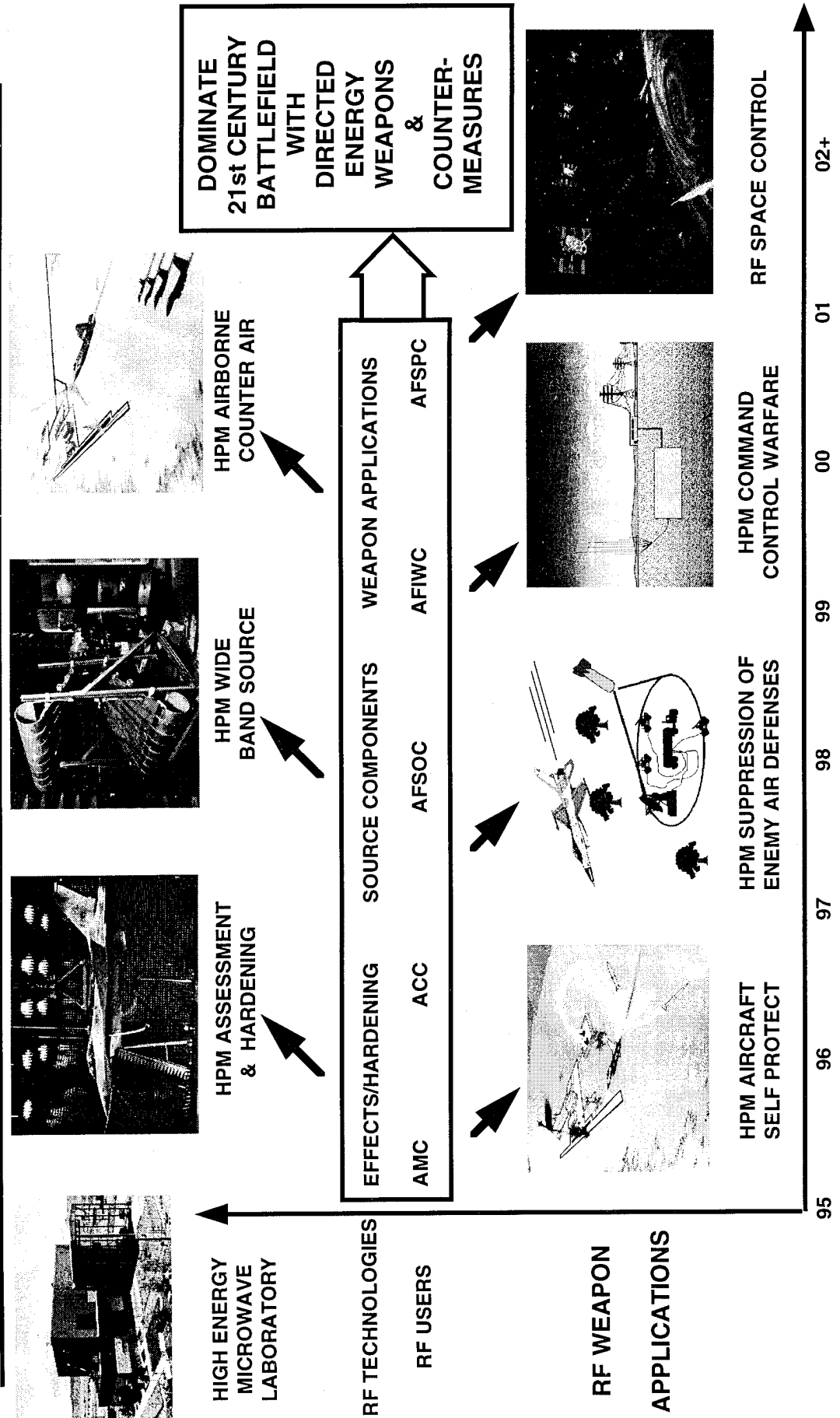
CHANGES FROM LAST YEAR

RF Weapons was reorganized during FY 93 from basic technology subthrusts to an integrated approach focusing on specific military applications. This realignment reflected the increasing maturity of RF weapons technology and the potential for near-term RF weapons meeting high priority user needs. FY95 has witnessed further evolutionary changes to include-

HPM Aircraft Self Protection (ASP): HPM ASP has expanded, and now encompasses both Air Combat & Mobility Commands' requirements for



ADVANCED WEAPONS RF WEAPONS



infrared countermeasures. The RF Effects portion of this program has expanded correspondingly, and projected ASP field demonstrations are now being planned.

HPM Command Control Warfare (CCW): HPM CCW has also grown in consonance with the increased emphasis on Information Warfare by the Air Force and Joint Staff. HPM CCW has also assumed responsibility for AF HPM wideband source technology development.

Compact Toroid Completion: The DNA funded program on compact toroid X-ray generation has achieved its near-term goals, and will become inactive pending further dollars and direction from DNA.

MAJOR ACCOMPLISHMENTS

HPM Sources are the key to successful RF Weapons Applications, and have made major progress. The Aircraft Self Protection project has supported wide band source technologies with the following significant accomplishments:

- Delivery of a multi-GW solid state switched source. This electronically steerable HPM array has a substantial sustained rep rate.
- Delivery of a Multi-GW gas switched source with an improved antenna. This system is the pilot device for a large scaled up source presently under construction.
- Design of a generic, compact pulse power system for increasing wide band efficiencies to 100%.
- Construction of novel compact antennas such as a wide band, high-gain impulse radiating antenna.

The Suppression of Enemy Air Defenses (SEAD) program, on the other hand, has supported narrow band source technologies. In particular -

The magnetically insulated line oscillator (MILO) has delivered a record-breaking narrow band output power.

Command Control Warfare (CCW) and Counter Air (CA) are leveraging the preceding source technologies for their goals. They have, however, achieved several mission unique accomplishments:

- Construction of a miniature monocone antenna for a compact air-delivered submunition.
- Transition of explosively driven magneto cumulative & magneto hydrodynamic pulse power drivers from the laboratory to the field

in preparation for later system demonstrations.

RF Effects programs have also undergone major expansion and achieved significant results:

- Completion of the F-16 EMI/EMC program. This effort assessed the susceptibility of modern fighters to both hostile and inadvertent friendly RF threats, and is a major consideration in the Aircraft Self-Protection (ASP) application.
- RF assessment of current-generation guided missile threats.
- Conducted RF testing of complete air defense systems for SEAD.
- Completed RF tests of a various CCW & CA goals.

All of these user need/goal oriented efforts have received major help from a PL developed testing method which enables effects data acquisition at over ten times the rate of previous methods.

MILESTONES

The technology activities of the RF Weapons Thrust are directed towards several User mission applications which will culminate in a series of critical field demonstrations during the next five years. The most critical program milestones are associated with generating the RF effects requirements database, demonstrating candidate HPM sources, and integrating the down-selected systems into practical packages for the mission applications. The calendar of major events are shown below:

Mission Application	Effects Complete	Source Demo	Brassboard Demo
ASP	FY96	FY96	FY98
SEAD	FY97	FY97	FY99
CCW	FY98	FY99	FY00
CA	FY98	FY99	FY00
ADT	FY96	FY96	FY96

Table 4-1. RF Weapons Milestone Calendar

The Effects & Hardening and Enabling Technology programs are more pervasive efforts with broader goals. Some notable efforts within the Effects & Hardening program, however, include planned RF effects testing and hardening studies of several advanced aircraft in the near future.

THRUST 5: SPACE CONTROL ASSESSMENTS

USER NEEDS

Air Force Space Command (AFSPC) and Space and Missile Systems Center (SMC)

The requirements for AFSPC are taken from their Counterspace and Surveillance Mission Area Plans (MAPs), which together comprise the Space Control Mission Area. The requirements for SMC have been formed through contacts with individual System Program Offices and through the Technical Planning Integrated Product Team Roadmap process supporting the MAPs. Space Control operational functions fall into four areas: Space Surveillance, Warfare Simulations (WarSim), Battle Management Command, Control, Communications, and Intelligence (BMC³I), and Protection. Together, surveillance and WarSim provide situation scenarios, BMC³I is the decision and tasking process, and protection is the resulting action. Assessment of action taken is done in BMC³I, WarSim and surveillance functions thereby closing the command and control loop. Functional requirements for the Counterspace and Surveillance MAPs are:

- **Space Surveillance:**
 - Provide indications and warnings
 - Generate non-cooperative launch data
 - Space object identification (spacecraft/debris) and mission payload assessments (SOI/MPA)
 - Update orbital data and space catalog
 - Integrate with terrestrial reconnaissance, surveillance, and intelligence operations
- **WarSim:**
 - Simulate space system operations in combat
 - Asset vulnerability assessments
 - Dynamic training for space combat exercises
 - Real-time space combat status, predictions, and options to battlefield commanders
 - Space asset battle damage assessment (BDA)
- **BMC³I:**
 - Develop operations plans
 - Battlefield preparation support
 - Centralized control and decisions
 - Decentralized execution procedures
 - Real-time support to battlefield components
- **Protection:**
 - Threat warning/attack reporting
 - Avoid and withstand attack
 - Sustainment and replenishment of forces
 - Deny adversary use of US/Allied space assets

GOALS

Technology developments are needed in each of the Space Control functions. The Phillips Laboratory is advancing technologies to improve operational force capabilities to maximize situation awareness, accelerate the decision and tasking process, and protect US/Allied space systems. An integrated research approach is planned to provide proper levels of capability in each functional area so that operational forces have balance across all missions. Specific goals are:

- Develop multi-threat warning/protection technologies.
- Develop a hardened space sensor.
- Develop satellite lethality and assessment models for four selected assets.
- Provide advanced sensor design and assessments for multi-spectral, multi-sensor data analysis workstation.
- Complete space payload assessment and environmental interaction experiments.
- Initiate HPM application concept studies.

MAJOR ACCOMPLISHMENTS

There were many notable accomplishments during FY95. These include new analysis tools for vulnerability, susceptibility, and survivability of space assets, developments in laser vulnerability assessments for the GBL and ABL programs, and continued improvement in meeting the Intelligence Data Analysis System for Spacecraft (IDASS) and the Signature Identification and Contamination Interaction Measurements (SICIM) goals.

FY95 Space Control Protection activities included the first deliverable version of the Debris Analysis Workstation in support of the space protection mission. It was delivered to the US Army Theater High Altitude Area Defense Office, the White Sands Missile Range Flight Safety Office, AFOTEC, and the Air Force Studies and Analysis Agency. The Debris Analysis Workstation is a suite of software analysis tools developed to assess debris hazards from on-orbit breakups, space tests, missile engagements,



spacecraft operations, and natural hazards such as micrometeorites. The workstation quantifies the current space debris environment, assesses debris hazards to DoD assets, and investigates ways to reduce these hazards

AFSPC space intelligence and surveillance needs are being addressed by the Satellite Interactions and Payload Assessments effort, and will provide the capability for space object identification and satellite orbital maneuver detection in support of the space surveillance mission area plan. Major accomplishments include software development for mission sensor analysis of missile launches and spacecraft maneuvers. The analysis capability has been upgraded to include simulation of short and midwave infrared radiances that are scene specific.

The RF Space Control Technologies program has developed an analysis tool called Predictive RF Effects Coupling Tool which is designed to access a satellite information database in support of the space protection mission. This new statistical methodology is very useful at the component level to estimate the effect of RF energy on electronic systems. Preliminary assessments of several space systems to potential interference has shown promising results. These assessments will be used for more detailed investigations of predicted susceptibilities.

The Satellite Assessment Center's FY95 activities included continued refinement of laser vulnerability assessment tools and satellite models, and the publication of a first-ever report on satellite vulnerabilities to laser fluences in projected threat scenarios. This represents a crucial step in defining technology and system requirements for future ground-based laser applications.

In the Airborne Laser arena, lethality criteria were experimentally validated for fuel tanks of various theater ballistic missiles. Experiments utilized a variety of laser power levels and wavelengths, culminating in full-scale tests using the high-power Mid Infrared Advanced Chemical Laser at the White Sands Missile Range. The demonstrator program is producing more confidence in potential use of lasers for a variety of possible missile defense scenarios.

Phase one of the implementation of the Intelligence Data Analysis System for Spacecraft was completed, with development and demonstration of a Graphical User Interface and incorporation of an advanced image display, attitude estimation, motion estimation tools, acquisition geometry visualization, and interactive satellite Computer Aided Design overlay tools. These software capabilities will provide the space warfighter with enhanced

interim tools to exploit optical space surveillance data. This will ultimately demonstrate multi-sensor data fusion technologies, enabling USSPC to exploit data from all contributing sensors within the Space Surveillance Network for enhanced Space Object Identification and Mission Payload Assessment.

CHANGES FROM LAST YEAR

There have been no significant changes since last year in the direction, focus, investment strategy, or schedule for this thrust.

MILESTONES

Space Control Protection:

- Signature Identification and Contamination Interaction Measurements software transfer to USSPC Combined Intelligence Center (FY97)
- Operational Debris Analysis Workstation (FY97)
- Debris Observations Database (FY97)

Satellite Assessment

- Satellite RF Vulnerability Assessment Capability -- integration and validation (FY97)
- Increased satellite degrade, disrupt and deny (D³) assessment capability. (FY97)
- Operational Intelligence Data Analysis System for Spacecraft. (FY98)

GLOSSARY

A

ABL Airborne Laser
 ABLEX Airborne Laser Experiment
 ACC Air Combat Command
 ADONIS AMOS Daytime Optical Near-Infrared Imaging System
 AEOS Advanced Electro-Optical System
 ADT Active Denial Technology
 AFAE Air Force Acquisition Executive
 AFMC Air Force Materiel Command
 AFMC/ST Director of Science and Technology
 AFOSR Air Force Office of Scientific Research
 AFSOC Air Force Special Operations Command
 AFSPC Air Force Space Command
 AFTAC Air Force Technical Applications Center
 AL Armstrong Laboratory
 ALC Air Logistics Center
 AMC Air Mobility Command
 AMOS AF Maui Optical Site
 ASAT Antisatellite
 ASC Aeronautical Systems Center
 ASP Aircraft Self Protection
 ATD Advanced Technology Demonstration

B

BDA Battle Damage Assessment
 BMDO Ballistic Missile Defense Organization
 BMC3I Battle Management Command, Control, Communications, and Intelligence

C

CA Counter Air
 CCW Command and Control Warfare
 COIL Chemical Oxygen-Iodine Laser
 COPUOS Committee on Peaceful Uses of Outer Space
 CRDA Cooperative Research and Development Agreement
 C3I Command, Control, Communications, and Intelligence

D3
 D4
 DEW
 DMSP
 DNA
 DOD
 DOE
 DPL
 DSP

EM
 EMP
 ESC

FAA
 FTA

GaAs
 GBL
 GEO
 GHz
 GW

HEML
 HPM
 HSC
 Hz

IDASS
 IR
 IRCM
 IR&D

D

Degrade, Disrupt, Deny
 Deny, Disrupt, Degrade, Destroy
 Directed Energy Weapon
 Defense Meteorological Satellite Program
 Defense Nuclear Agency
 Department of Defense
 Department of Energy
 Diode-Pumped Laser
 Defense Support Program

E

Electromagnetic
 Electromagnetic Pulse
 Electronics System Center

F

Federal Aviation Administration
 Focused Technology Area

G

Gallium-Arsenide
 Ground-Based Laser
 Geosynchronous
 GigaHertz
 GigaWatt

H

High Energy Microwave Laboratory
 High Power Microwave
 Human Systems Center
 Hertz

I

Intelligence Data Analysis System for Spacecraft
 Infrared
 Infrared Countermeasures
 Independent Research & Development

J		P	
JDL	Joint Directors of Laboratories	PACE	Point-Ahead Compensation Experiment
JPL	Jet Propulsion Laboratory	PILOT	Phased Integrated Laser Optics Technology
K		PL	Phillips Laboratory
km	kilometers	PMD	Program Management Directive
kW	kiloWatts	R	
kHz	kiloHertz	R&D	Research & Development
L		RF	Radio Frequency
LANL	Los Alamos National Laboratory	RL	Rome Laboratory
LANTIRN	Low Altitude Navigational and Targeting Infrared for Night	S	
LEO	Low Earth Orbit	S&T	Science & Technology
LESLI	Large Electromagnetic System Level Illuminator	SBIR	Small Business Innovative Research
LLNL	Lawrence Livermore National Laboratory	SEAD	Suppression of Enemy Air Defenses
LIME	Laser Induced Microwave Emission	SHIVA STAR	Free world's most powerful fast capacitor bank
LPD	Low Probability of Detection	SIE	Satellite Imaging Experiment
LPI	Low Probability of Intercept	SMC	Space & Missile Systems Center
M		SNL	Sandia National Laboratory
m	meter	SOI	Space Object Identification
mW	milliWatt	SOR	Starfire Optical Range
Malabar	PL Optical Facility in Melbourne, Florida	SPO	System Program Office
MAP	Mission Area Plan	S/V/L	Survivability/Vulnerability/Lethality
MOA	Memoranda of Agreement	SWC	Space Warfare Center
MOPA	Master-Oscillator Power-Amplifier	T	
MOU	Memoranda of Understanding	TAP	Technology Area Plan
MPA	Mission Payload Assessment	TEO	Technology Executive Officer
MSTRS	Miniaturized Satellite Tracking and Reporting System	TMD	Theater Missile Defense
MW	MegaWatt	TPDEW	Technology Panel for Directed Energy Weapons
N		TPIPT	Technology Planning Integrated Product Team
NASA	National Aeronautics & Space Administration	TW/AR	Threat Warning/Attack Reporting
NATO	North Atlantic Treaty Organization	U	
NLO	Nonlinear Optics	USSPC	US Space Command
O		W	
OSD	Office of the Secretary of Defense	WarSim	Warfare Simulations
		WL	Wright Laboratory

TECHNOLOGY MASTER PROCESS OVERVIEW

Part of the Air Force Materiel Command's (AFMC) mission deals with maintaining technological superiority for the United States Air Force by:

- Discovering and developing leading edge technologies
- Transitioning mature technologies to system developers and maintainers
- Inserting fully developed technologies into our weapon systems and supporting infrastructure, and
- Transferring dual-use technologies to improve economic competitiveness

To insure this mission is effectively accomplished in a disciplined, structured manner, AFMC has implemented the **Technology Master Process (TMP)**. The TMP is AFMC's vehicle for planning and executing an end-to-end technology program on an annual basis.

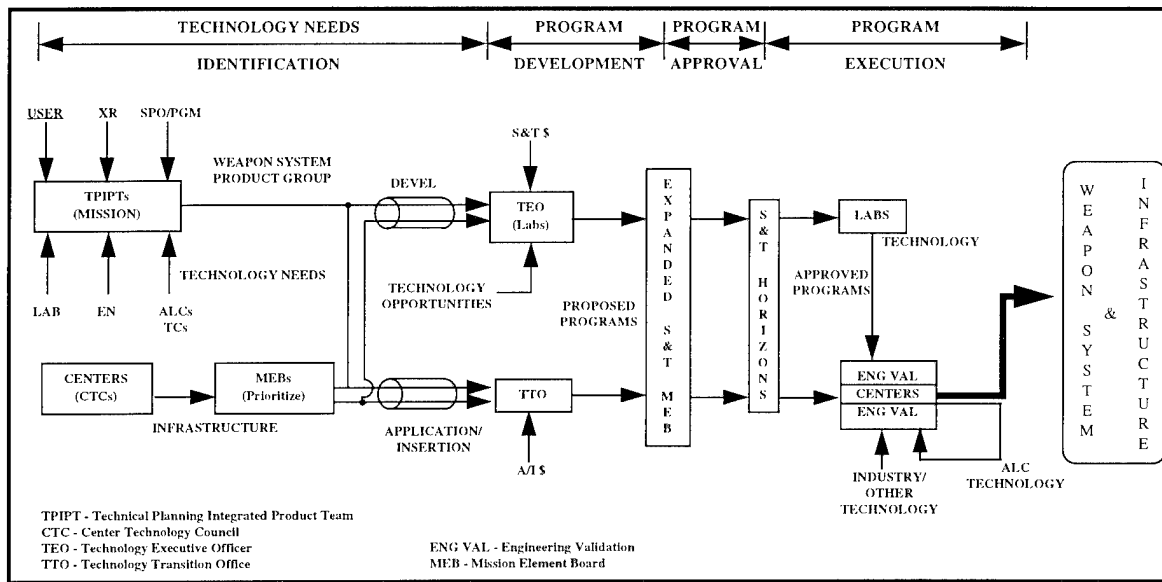


Figure 1 - Technology Master Process

The TMP has four distinct phases, as shown in Figure 1:

- Phase 1, **Technology Needs Identification** -- Collects customer-provided technology needs associated with both weapon systems/product groups (via TPIPTs) and supporting infrastructure (via CTCs), prioritizes those needs, and categorizes them according to the need to develop new technology or apply/insert emerging or existing technology. Weapon system-related needs are derived in a strategies-to-task framework via the user-driven Mission Area Planning process.

- Phase 2, **Program Development** -- Formulates a portfolio of dollars constrained projects to meet customer-identified needs from Phase 1. The Technology Executive Officer (TEO), with the laboratories, develops a set of projects for those needs requiring development of new technology, while the Technology Transition Officer (TTO) orchestrates development of a project portfolio for those needs which can be met by the application/insertion of emerging or existing technology.
- Phase 3, **Program Approval** -- Reviews the proposed project portfolio with the customer base via an Expanded S&T Mission Element Board and, later, the AFMC Corporate Board via S&T HORIZONS. The primary products of Phase 3 are recommended submissions to the POM/BES for S&T budget and for the various technology application/insertion program budgets.
- Phase 4, **Program Execution** -- Executes the approved S&T program and technology application/insertion program within the constraints of the Congressional budget and budget direction from higher headquarters. The products of Phase 4 are validated technologies that satisfy customer weapon system and infrastructure deficiencies.

TMP Implementation Status

The Technology Master Process is in its first full year of implementation. AFMC formally initiated this process at the beginning of FY94 following a detailed process development phase. During the FY95 cycle, AFMC will use the TMP to guide the selection of specific technology projects to be included in the Science and Technology FY98 POM and related President's Budgets.

Additional Information

Additional information on the Technology Master Process is available from HQ AFMC/STP, DSN 787-785, (513) 257-7850.

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